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Optical Modes in Graphene on Silicon Photonic Crystal Membrane

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We report on investigation of optical modes in graphene suspended on a silicon photonic crystal membrane [Fig. 1(a)]. Depending on the relations between the structure period a, the graphene surface plasmon polaritons wavelength λ_{SPP}, the silicon membrane effective wavelength λ_{phot} and the free-space wavelength λ_0 (typically $\lambda_{SPP}<\lambda_{phot}<\lambda_0$) we identify the following regimes of an electromagnetic wave interaction with the structure: (1) metamaterial $a<\lambda_{SPP}$, (2) plasmonic $\lambda_{SPP}<a<\lambda_{phot}$, (3) photonic $\lambda_{phot}<a<\lambda_0$ and (4) diffraction grating regime $\lambda_0<a$. We study numerically a 1D silicon grating with graphene and absorbance of the normally incident wave [see resonances in absorbance in Fig. 1 (b) and (c)] with variation of geometrical and material parameters. Increasing the period of the grating leads to smearing of the distinct plasmonic peaks into a broad resonance. We also discuss potential strategies for absorbance maximization. Graphene on silicon photonic crystal is a promising platform for terahertz and infrared absorbers, filters, sensors and photodetectors [1, 2].

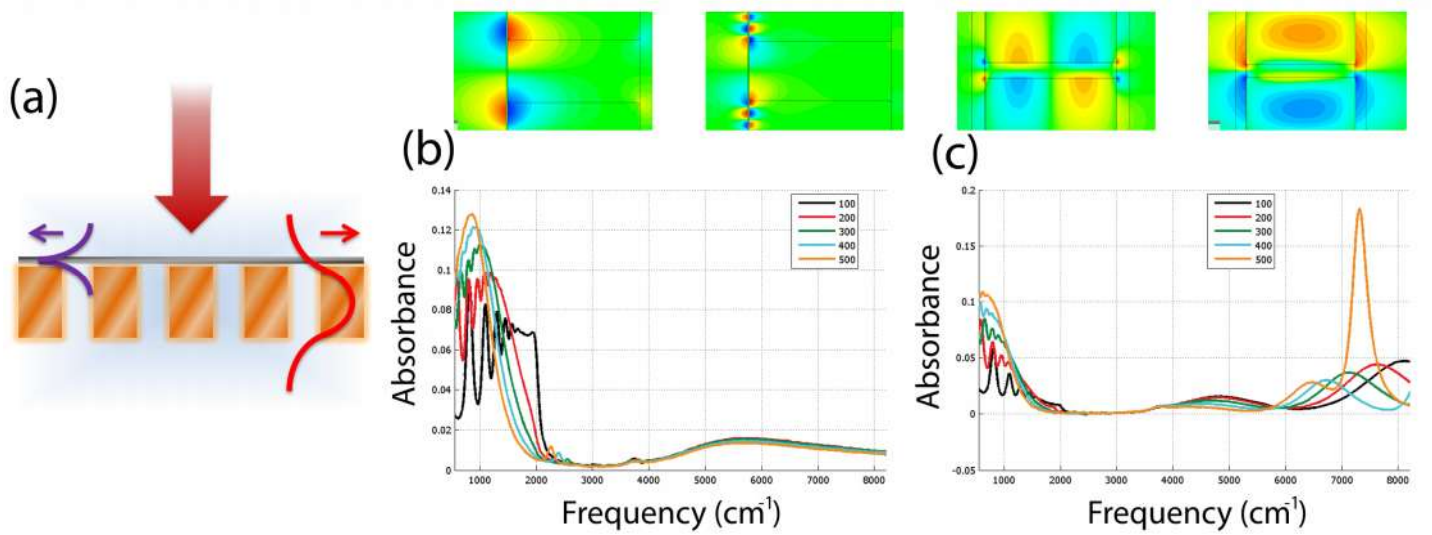

Figure 1. (a) Normally incident electromagnetic wave can excite plasmonic modes in graphene as well as photonic modes in silicon grating. Simulated absorbance spectrum for the 100 nm (b) and 500 nm (c) thick silicon membrane and graphene's E_F= 0.3 eV for the period a = 100 – 500 nm. Insets show examples of the fields of plasmonic (two left figure, at low frequencies) and photonic (two right figures, at high frequencies) modes.

References

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